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TECHNOLOGY TRANSFER PROGRAM (TTP)

FINAL REPORT

QUALITY ASSURANCE SYSTEM

QUALITY ASSURANCE

EXECUTIVE SUMMARY

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PREFACE

This document is a summary of a two volume report on Quality Assurance resulting from the Shipbuilding Technology Transfer Program performed by Levingston Shipbuilding Company under a cost-sharing contract with the U.S. Maritime Administration.

This summary provides a condensation of the findings and conclusions of Livingston's study of the Accuracy Control and Quality Control systems currently in use in the shipyards of Ishikawajima-Harima Heavy Industries (IHI) of Japan. Livingston gratefully acknowledges the generous assistance of IHI consulting personnel and all of the IHI personnel in Japan who made this study possible.

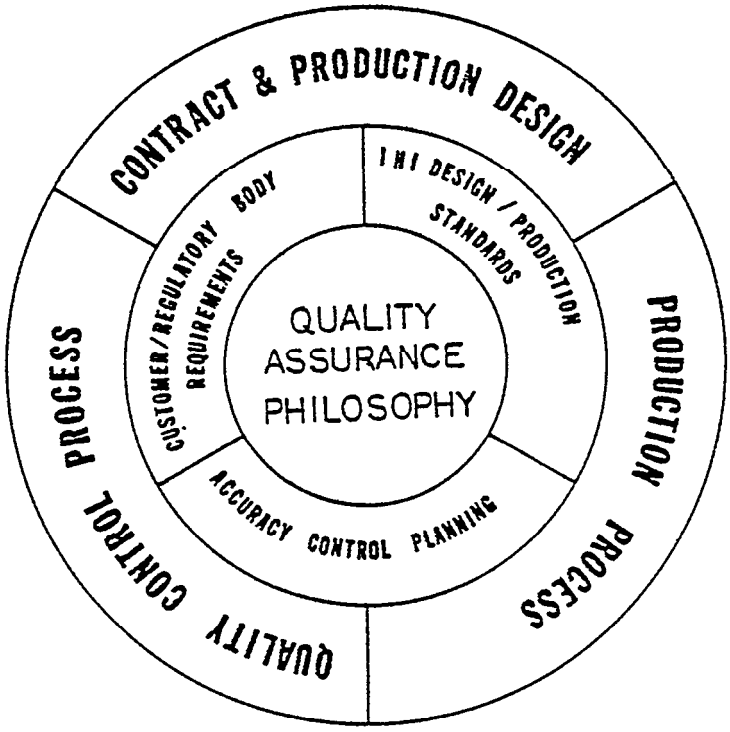
For details concerning the Technology Transfer Program or of the information contained herein, refer to Volume I - Findings and Conclusions, and Volume II - Appendices, of this report.

EXECUTIVE SUMMARY

THE IHI CONCEPT OF QUALITY ASSURANCE

The IHI concept of Quality Assurance cannot be identified as a separate function or organization. Rather, it is a management, design and production philosophy found in continuous application at all levels of the organization.

The Quality Assurance function can best be described as an interactive system comprising the elements of regulatory body and customer specification requirements, IHI standards, and Accuracy Control requirements. These data form the basis for all design and production processes. Using this base, discrete organizational elements and methods and techniques were developed to apply and ensure adherence to these requirements in all design/production activities. In this system, Quality 'Assurance is an inherent aspect of the production process rather than a specifically defined organization whose charter is to "police" the end result of various production processes.



This system incorporates two discrete organizational functions: Accuracy Control and Quality Control. The first function, Accuracy Control, is in reality a production planning and control process which establishes the basic scheme for ship production and, directly or indirectly, controls production methodology throughout ship design and construction.

The second function, Quality Control, is a management activity which supervises the overall inspection system, performs sample inspection and all nondestructive test (NDT) inspections, monitors production processes and techniques, evaluates quality control documentation, provides liaison with customers and regulatory agencies, and collaborates with Accuracy Control groups in perfecting production activities to obtain the highest possible accuracy and overall quality.

ACCURACY CONTROL

Accuracy Control is the underpinning of the IHI production system. This concept and its application has not only vastly improved the quality of IHI products but is a major factor in the outstanding productivity of IHI shipyards. The Accuracy Control system is not a single organization or function. Rather, it consists of four separate groups (one in design and one in each of three workshops) which are charged with a series of responsibilities.

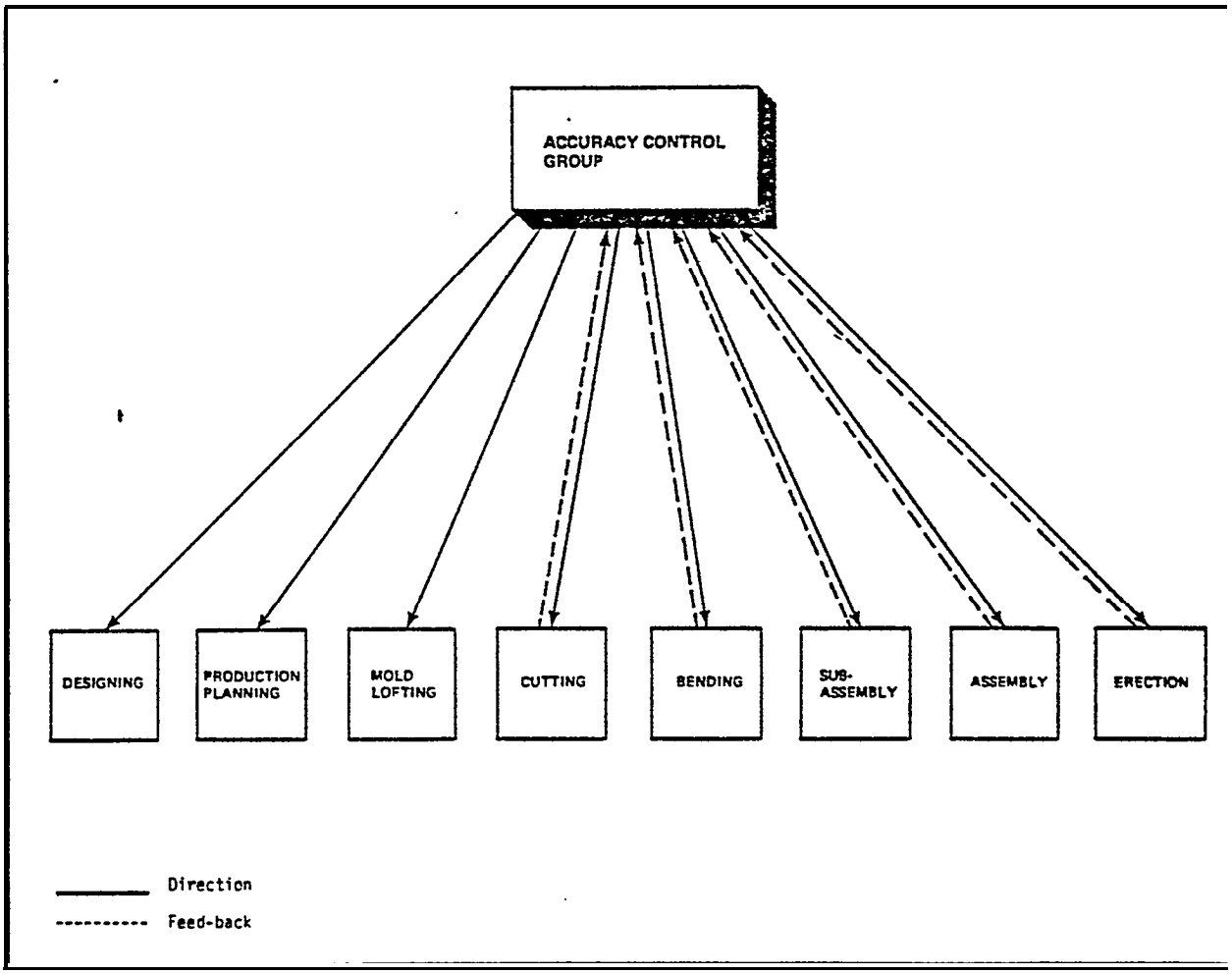
Accuracy Control begins in the shipyard immediately subsequent to completion of "Basic" design and prior to the start of detail design development. The initial activity is basic planning involving: ship work breakdown; determination of fabrication sequence and methods; establishment of critical dimensions, baselines and added material; determination of the erection sequence; and development of the plan for shipwrighting.

Subsequently, detailed "Check Sheets" are prepared specifying the measurements, dimension requirements, measuring equipment and frequency, for each item or assembly as it moves through the production process.

After this planning is completed, the Accuracy Control "Field Activity" is initiated where Accuracy Control personnel become active in the monitoring and measuring of plates, shapes, sub-assemblies and assemblies. The express objective of this planning and field activity is to maintain the highest accuracy possible in the major hull "blocks" or modules. The intent is to minimize to the greatest degree possible the work during the erection sequence. High accuracy in each hull module naturally means better Fit, less re-work and greater efficiency during later production stages, particularly during erection,

Accuracy Control personnel are also concerned with the collection, analysis and feed-back of information to affected groups on quality, production processes and methods, work flow and sequencing. This activity not only assists in the correction of errors but also in the constant improvement of the IHI production system.

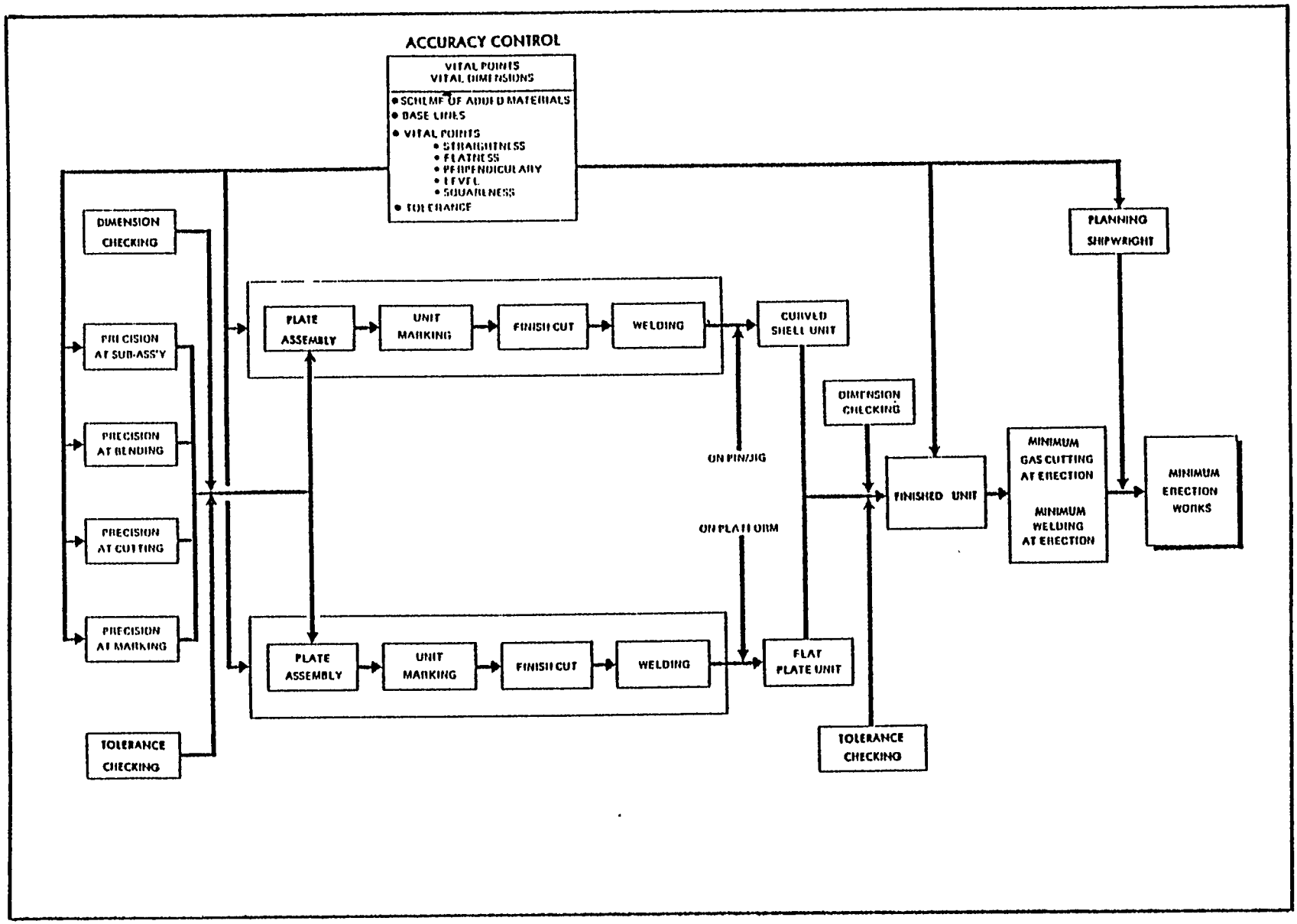
The Accuracy Control concept was the offspring of a management philosophy introduced by the President of IHI approximately 15 years ago. The application of the concept to the actual production process required many years of trial and error; but since its inception, Accuracy Control and its counterpart, Quality Control, have developed into the "standard" method governing ship construction.



The concept of Accuracy Control pervades all work and all levels of personnel with a concern for good workmanship and exactness. All work is expertly performed to exacting standards and, therefore, all successive work becomes easier and demands only the time required for the work planned for each work station. Poor workmanship, errors or material requiring clean-up is never passed from one work station to the next and only precise and error-free material flows through the building process, resulting in a sustained high level of productivity.

The development of the Accuracy Control concept within IHI has superseded and obviated any necessity for a "Quality Assurance" function. In fact, the combined Accuracy Control and Quality Control system is Quality Assurance at IHI. The surprising aspect to this fact is that Accuracy Control is in reality a production planning and control process. Throughout the Accuracy Control activity, the intent is to thoroughly and properly plan each production process on each component, subassembly and assembly to obtain the highest possible accuracy. This activity occurs simultaneously with all other planning and is not separately identifiable from any other aspect of production planning.

It is interesting to note that in the IHI system, Accuracy Control is the method or means utilized not only to achieve high product quality but also the greatest productivity. These two objectives are achieved simultaneously and automatically. The "before-the-fact" planning accomplished by Accuracy Control establishes the basis for all subsequent planning and the "after-the-fact" measurement, data analysis and correction of methods, sequences and processes serve to perfect not only the planning but the production process itself. This continual improvement of planninq data and



CONCEPT OF ACCURACY CONTROL IN THI

production processes results in a perpetual refinement of production-techniques and a concomitant increase in productivity. Product quality in this scheme is almost a by-product of this continual improvement cycle.

The Accuracy Control concept is equally important as a tool for shipyard management, particularly middle or first-line managers. Both detail design and production planning are influenced by the Accuracy Control planning activity. Fabrication sequences and the techniques and methods to be used to achieve the highest accuracy and throughput are also directly influenced by Accuracy Control planning. Accuracy Control standards and Check Sheets prescribe the necessary workmanship requirement for each piece part and each successive unit. Prescribed measurements and measurement methods and instruments are the result of Accuracy Control study and planning. The erection sequence and the plan for shipwrighting, both resulting from Accuracy Control activity, detail the flow and work requirements for final ship construction and finishing.

Over the years these planning tasks have been perfected, along with a highly developed set of standards, to the point where all IHI managers, foremen, assistant foremen and workers are intimately familiar with them and rely exclusively on the information thus developed. Each manager, foreman and assistant foreman has precise and highly detailed guidance data for each work task assigned to him. All detailed planning and schedule data are based on the studies and the overall planning for fabrication and ship

This deductive planning method proceeds from the highest to the lowest levels of work all based on the objective of keeping the highest degree of accuracy possible at each stage of production.

With all of this planning and scheduling data precisely developed, managers, foremen and assistant foremen have little to do except to execute the work according to the plan. Their attention can be properly placed on the optimum positioning of material (within a work station), effective application of personnel, and on schedules and work quality. Unlike their American counterparts, they are able to place their emphasis on getting the work accomplished well and on schedule rather than on an exorbitant paper-work load, committee action, and "brush fires" usually related to errors in design, fabrication or assembly, or to "up-stream" or "down-stream" schedule slippages.

Managers at all levels know exactly what has to be done, when, and with what facilities and procedures. Only major exceptions cause any redirection of the established routine and these exceptions are generally not allowed to happen. Under this system, managers are free to accomplish their assigned work and to resolve problems among themselves at the lowest level practicable. Interference with their assigned work is a rarity mainly because interference is unnecessary and because all management and workers are aware and in support of the stringent schedules planned for each ship. These schedules are also a part of each person’s concern with Accuracy and Quality Control. Obviously, only superb workmanship can be tolerated in a system geared to hour-by-hour schedules.

The effect of this system on people at all levels of the organization is far-reaching. Although very little mention of Accuracy Control is made during visits to the IHI shipyards, it is apparent that the concept and its

application have become indigenous to the work habits and the routine of the workforce. More obvious during these visits was the emphasis placed on Quality Control but only because discrete functions and organizations are easier to explain than underlying concepts.

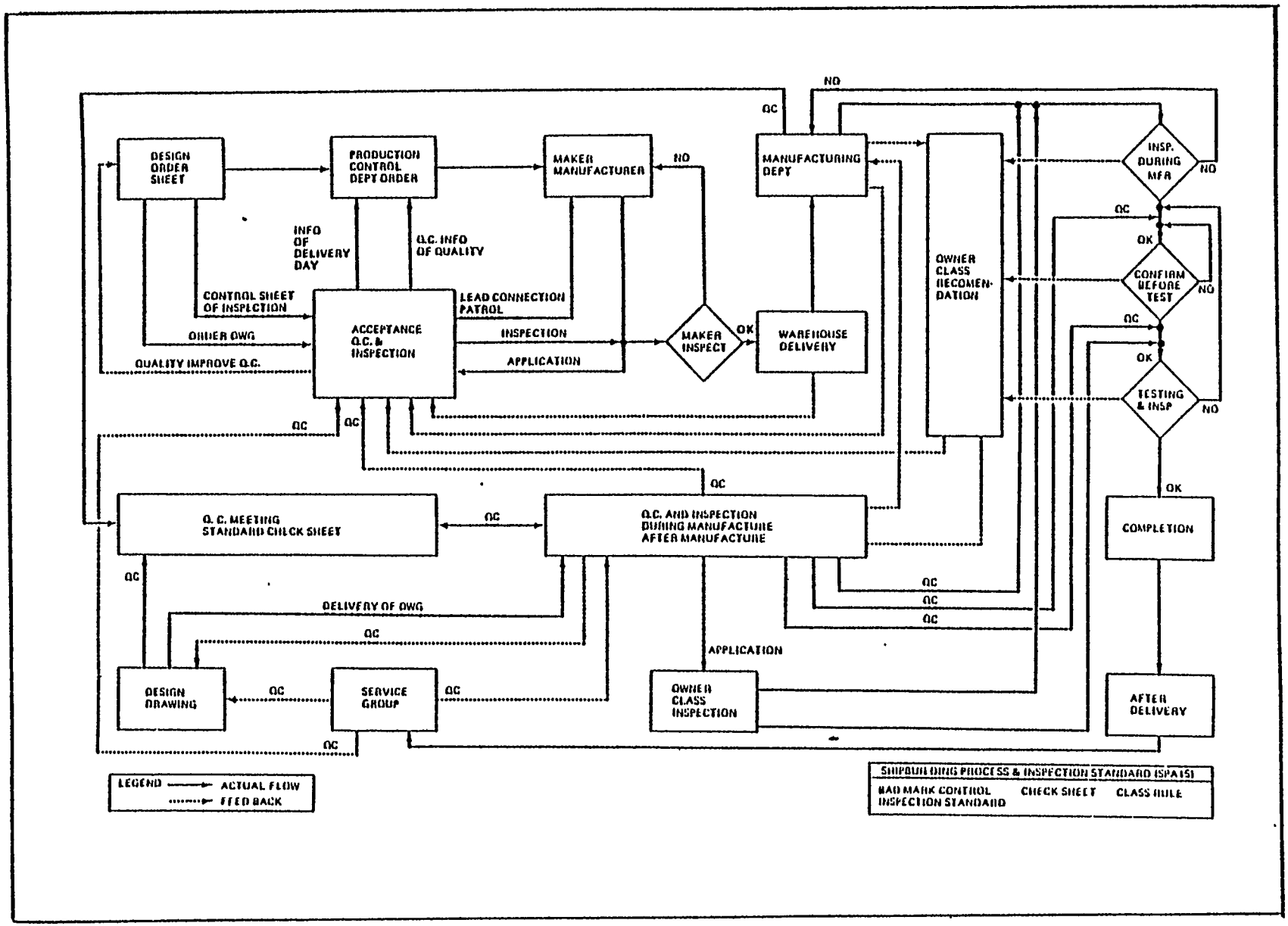
Accuracy Control within IHI is the guiding principle that provides all planning, design and production functions with the basis and the goal for their various activities. It is the guiding policy that gives form to the system and makes it comprehensible to the people who operate it.

QUALITY CONTROL

The Quality Control function at IHI is a highly sophisticated inspection and data recording/reporting system. Although this function is organized in a single department, the Quality Control system extends throughout the yard and is integral to every workshop and trade. Nest of the inspections are performed within the production department work groups by each worker, assistant foreman, and a member of the work group specifically designated to do nothing but check completed work. Each of these inspections are recorded on a Quality Control Check Sheet. Quality Control Department personnel sample inspect approximately five percent of all such work and customer/regulatory agency inspectors perform similar inspections at the assembly and ship erection stages. The IHI Quality Control system follows the "standard" Quality Control approach used by all Japanese shipyards.

Quality Control's role begins in the design process where quality requirements are input to the design engineers on an overall and a drawing-by-drawing basis. All drawings used for outside procurement are checked by Quality Control prior to release. Another aspect of Quality Control in the design process is in the development of quality specification requirements for purchased material and assistance in the development of Accuracy Control Check Sheets for the components and units built by the shipyard.

The responsibilities of Quality Control in the production process range throughout the typical functions of on-site vendor inspections, receiving inspection, in-process inspections, component and system testing, NDT inspections, and dock-site, builder and final acceptance trials. Throughout the process, Quality Control establishes the requirements, receives and records



GENERAL FLOW OF QUALITY CONTROL (IHI)

data (whether or not performed by a Quality Control inspector) and actively monitors the quality of workmanship and product at each stage of production.

The majority of inspection is performed by the workers at all stages of production. For example, warehousemen perform all material and component receiving inspection except for special components which are not routinely purchased. Welders perform a self-check of all of their work and when satisfied identify their work by affixing their signature. Another worker in each group (usually six to eight people) is assigned permanent responsibility for checking the quality of the work accomplished by all members of his group. This "checker" has no other duties. Each group's work is also inspected by the responsible assistant foreman prior to acceptance and movement of the piece or assembly under construction.

Because of the reliance placed on the individual worker, the group checkers and the assistant foremen, the Japanese Quality Control activity is more one of quality management. The Quality Control group establishes quality requirements for each product, educates and trains foremen, assistant foremen and workers in the accomplishment of the required quality, collects applicable data for analysis and for verification of work to quality standards and customer specifications, and generally monitors the production process to assure that established requirements are being met. In the performance of these duties, Quality Control representatives play an important part in virtually all aspects of design, production planning and the production methods utilized for ship fabrication and construction.

The most important procedure used in the IHI Quality Control system is the 3-point inspection system employed to assure the accuracy of the fabricated components and assemblies and the high quality of all weldments throughout the production process. In this regard, a single check sheet is used for each

unit at each prodction stage which is signed by the assistant foreman, the group checker and finally by the Quality Control inspector on a number of various conditions which may exist on the work at each work station. Thins Check Sheet is used throughout the inspection process to document deficiencies and corrective action. All deficiencies are corrected by the worker making the error. The sheet is also used by assistant foremen to remedy continuing problems in cutting, fitting or welding by identifying persistent problems and either obtaining a correction in design *or* educating workers in proper techniques to prevent a recurrence.

During the processing of steel and outfitting, all work, is identified either by worker's signature on welds or by means of work station personnel rosters. By this means, the group leader and checker/inspectors can identify specific individuals responsible for the work. A weighted factor (based on the importance of the work performed) is applied by the inspector to each error to achieve a sumnary "grade" or "bad mark" for each item inspected. The purpose of this system is related only to each individual's pride in his workmanship. No disciplinary action is taken as a result of "bad marks", it is simply a means of publicizing superior or poor work both to the individual worker and to his work group. These records are used to contin-ualy assess the performance of each group. Quality performance reports are posted in each work area.

One of the principal functions of the Quality-Control activity is to assure the safety and well being of the individual workers. The Japanese recognize the importance of these personnel-oriented aspects of production. Their concern is based on the established fact that poor quality results from unsafe working conditions and/or unhappy workers. Therefore, Quality Control involves itself in all decisions concerning this type of personnel relations.

CONCLUSION

Together, the Accuracy Control and Quality Control functions form a complete system for the detail planning and control of virtually every aspect of the production process. Because quality is the expressed objective of all shipyard practice, this system pervades all activities and levels of yard organization and has become an inherent part of the attitudes and work habits of the IHI workforce. Its many benefits are apparent in the constantly improving productivity rates of IHI yards, the established and smoothly working production system, management/worker relations, and in remarkably short building schedules and low costs.

Livingston Shipbuilding has instituted a portion of the Accuracy Control concept in its yard in Orange, Texas. There are several possible alternatives to the institution of the-entire Accuracy Control system: as a planning and production control function; as an extension of the Quality Assurance activity; and as a product improvement function. Livingston chose to experiment with the use of Accuracy Control in conjunction with its traditional Quality Assurance activity and has already obtained some significant benefit through the development and application of Accuracy Control Check Sheets in the measurement of components and assemblies during production of the modified Future 32 bulkers. This experiment has shown the potential benefits of even one portion of the Accuracy Control concept, however, it has made evident the difficulty of implementing a new and radically different methodology into a traditional American shipyard.

The concept of Accuracy Control is subtle but far-reaching in its effects. Although the emphasis is on quality, Accuracy Control is in

reality the basis for all shipyard activity. Through this single mechanism, the basic planning is accomplished for all production activity. The execution of the planning is then monitored (by all personnel) and constantly corrected and improved wherever possible. The attempt by all work groups to attain-high accuracy *in* their completed work results in a finite reduction of re-work; movement of only good, high quality and clean work from one area to another; and the consequent ability to accurately plan and schedule each work station due to the absence of defects.

In spite of all of these desirable characteristics, the Accuracy Control concept is not easy to implement. The concept requires a somewhat different management philosophy and a radically different approach to typical American organization and practice. IHI has spent 15 years in its full development and is still improving and modifying its application. This difficulty initially arose from the fact that there was no defined system within which to implement the concept. Rather, the system had to be developed over many years.

Having an already developed system as guidance should allow the adoption of any or all of this concept into U.S. yards in a relatively easy manner. However, the Accuracy Control concept corresponds better with the Japanese culture, philosophy and life style and is in many ways contradictory to American concepts of organization and socio-economic structure. American relationships in management and labor, and of government in private enterprise, do not closely correspond to those of Japan. And, perhaps most importantly, the high mobility of the U.S. workforce militates against the perfection of *any* such

system to the same degree enjoyed by the Japanese.

Certainly, a great deal of "tailoring" would be required to successfully adopt the Accuracy Control concept. But, even a "tailored" model of this sophisticated system could greatly benefit **U.S.** yards. The experiment currently being held at Livingston has proven that even a portion of the system can yield positive and beneficial results. Undoubtedly, a more thorough understanding and application of other parts or all of the system can improve both product quality and, ultimately, productivity.